American National Standard
for Information Technology—

Geographic Information Framework – Data Content Standards For Transportation Networks: Roads

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for Information Technology

Geographic Information Framework
Data Content Standards
For Transportation Networks: Roads
(Part XXX)

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Foreword

The primary purpose of the standard is to support the exchange of transportation data related to road networks. This standard also seeks to establish a common baseline for the content of road Transportation databases for public agencies and private enterprises. It seeks to decrease the costs of acquiring and exchanging road Transportation data for local, tribal, state, and federal users and creators of road Transportation data. Benefits of adopting the standard also include the long-term improvement of the geospatial Transportation base data, improved integration of safety and enforcement data, and streamlined maintenance procedures.

This is the first edition of this standard. However, this standard was preceded in development by the National Spatial Data Infrastructure (NSDI) Framework Transportation Identification Standard [1] and the National Cooperative Highway Research Program (NCHRP) 20-27 [2]. The Transportation Identification Standard served as the starting point for this standard but surpasses it by adding support for linear events.

This standard has been developed to fulfill one of the objectives of the NSDI, i.e., to create common geographic base data for seven critical data themes. These core themes are considered Framework data, reflecting their critical importance as geographic infrastructure. The Geospatial One Stop initiative is an e-government initiative of the federal government designed to expedite the creation of the seven Framework layers. This standard has been developed in response to the One Stop initiative to realize the goals and objectives of the NSDI.

Suggestions for improvements of this standard will be welcome. They should be sent to

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This standard was processed and approved for submittal to ANSI by the Accredited Standards Committee – INCITS/L1. Committee approval of this Standard does not necessarily imply that all committee members voted for its approval.

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American National Standard for Information Technology
Geographic Information Framework
Data Content Standards
(ANSI X.X.X2002)

1 Scope of this Standard

This standard defines the components of road networks, which along with rail, air, transit, and inland waterways, is one of five modes that compose the Transportation theme of the digital geospatial data framework. The primary purpose of the standard is to support the exchange of Transportation data related to road systems. It is the intent of this standard to develop a consensus around a set of common definitions for real world transportation features in order advance the goals of the Geospatial One Stop (GOS), including expediting the development of the National Spatial Data Infrastructure (NSDI). It is the intent of the standard to set a common baseline that will foster the widest possible set of applications of road transportation data for both user and producer. It is also to foster improvements in the common spatial data infrastructure through enhanced data sharing and the reduction of redundant data production.

This standard is a companion to the Geospatial One Stop Base Transportation Standard [3] document. There are a number of issues common to the transportation domain that, because of their broader applications are covered in the Transportation Base Standard document. Some of these issues, and their relevance for this standard, are discussed in the informative annexes. Subsequent revisions to this standard may lead to a more thorough treatment of these issues into this standard.

At a high level, the Transportation System described in the standard is made up of Transportation Features, which can have geographic locations and characteristics. These Transportation Features can be interconnected in various ways to represent Transportation Networks for path finding/routing applications. While the design team has considered the need for path finding applications, the level of data required by such applications is beyond the scope of many organizations. Specifically, many state and local government agencies do not have adequate data for routing purposes, and they do not have the budget to create and maintain this data. It is expected that the content in the standard should support the development of specialized networks for routing applications, but this level of information is not a requirement of the data standard.

The standard can be implemented using a variety of software packages and is designed to accommodate data encoded without geometry as well as to support the exchange of data encoded in a variety of geographic information systems. While this document touches on implementation issues, it is not intended to serve as an implementation specification. It is designed to accommodate the data associated with the complete road system at all levels of service and all functional classes that may be defined by a data-providing agency. It also accommodates assets associated with the road that are typically used for navigation, safety, and measurement.

This standard is not designed to exchange multi-modal transportation events. Therefore, every data exchange instance is unique, and where mixing across modes of transportation is not allowed. For example is not allowed to encode a Road Point that is connected to a Rail Segment.

This is not, however to preclude later revisions of this standard from accommodating intermodal data exchange.

The road standard applies to National Spatial Data Infrastructure (NSDI) Framework Transportation data produced or disseminated by or for the federal government. According to Executive Order 12906, Coordinating Geographic Data Acquisition and Access: the National Spatial Data Infrastructure [4], federal agencies collecting or producing geospatial data, either directly or indirectly (e.g., through grants, partnerships, or contracts with other entities), shall ensure, prior to obligating funds for such activities, that data will be collected in a manner that meets all relevant standards adopted through the Federal Geographic Data Committee (FGDC) process.

This standard relies extensively on the current ISO 19133 [5] standard for linear referencing. Linear Referencing Systems (LRS) are, in the strictest sense, not a central part of the road standard, and also are complex enough to warrant separate treatment. Users should refer to Annex A of the Base Transportation Standard for a profile of the ISO 19133 standard. The use of LRS and events is not added simply to support the requirements of Departments of Transportation; LRS is used as a technique to transfer road information between systems in a simple, flexible data structure that does not impose a specific segmentation or construct on the source database. LRS are used in this standard to support the exchange of asset information such as sign locations and pavement condition, as well as to support the placement of transportation statistics such as traffic counts or accident data along the roads, or the number of lanes, or speed limits.

A linkage between this standard and appropriate ISO standards for representing spatial features using the Unified Modeling Language (UML) has been developed. These upper-level classes are not necessarily unique to roads, or even to transportation. A specific Road Profile of those standards has been assembled as the base classes for this model, primarily to take advantage of geometry, topology, and metadata standards. Additional work by ISO TC211 and TC204 to harmonize GDF [6] and linear referencing standards is in progress in parallel with the development of this standard. Annex A contains a brief explanation of UML diagrams.

2 Normative References

The following standards contain provisions, which through reference in this text constitute provisions of this American National Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

[1] FGDC, *NSDI Framework Transportation Identification Standard*, April 2000.

[2] NCHRP 20-27, A Generic Data Model for Linear Referencing Systems, National Cooperative Research Program of the Transportation Research Board.

[3] ANSI, *Geospatial One Stop Base Transportation Standard.* ANSI X.X.X2003, Part XXXX, forthcoming.

[4] Executive Order 12906, Federal Register, Vol. 59, No. 71, 1994

[5] ISO 19133, *Geographic Information—Location Based Services Tracking and Navigation.*

[6] ISO/TR 14825 GDF, Geographic Data Files, Ver. 4.0.

[7] ISO 19109, *Geographic Information—Rules for Application Schema.*

[8] ISO 19110, *Geographic Information—Feature Cataloging Methodology*.

[9] ISO 19115, *Geographic Information—Metadata*.

[10] ISO 19107, *Geographic Information—Spatial Schema*.

[11] ISO 19103, *Geographic information - Conceptual schema language*

3 Definitions

Definitions applicable to the road standard are listed here. Other more general transportation terms are defined in the Base Transportation Standard. Users are advised to consult that document for a complete set of transportation definitions.

Anchor point – as defined in NCHRP 20-27, represents a physical location in the field that can be unambiguously described so that it can be clearly located in the real world using its description. An anchor point is a link between the computer representation of the road system and the real world. An anchor point must occur at the ends of an anchor section.

Anchor section – as defined in NCHRP 20-27, represents a section of roadway between two known and recoverable locations, i.e., anchor points. Anchor sections state the official, along the ground, length of a roadway segment.

Equivalence relationship (between road points) – used to indicate that a road point in one data set is equivalent to (i.e., has the same physical location as) one or more road points in another data set.

Equivalence relationship (between road segments) – used to indicate that a road segment in one data set is equivalent to (i.e., represents the same part of the physical roadway system as) one or more, whole or partial, road segments in another data set.

Road feature - any type of feature that constitutes or is associated with the Road system

Road path – (ROD_Path) defines a usage of an ordered list of whole or partial sections of physical roadway (i.e., road segments), e.g., an administrative route, such as Interstate 95, or a delivery route. Road path is the real world manifestation of the abstract TRN_Path as described in the Base Transportation Standard.

Road point – (ROD_Point) a point along the roadway system which has some special significance either for starting or ending a road segment or for representing a significant position along the roadway system such as the start or center of a bridge or the center of an intersection. Road Point is the real world manifestation of the abstract feature class, TRN_Point as described in the Base Transportation Standard.

Road segment – (ROD_Segment) represents a linear section of the physical road system designed for, or the result of, human or vehicular movement; must be continuous (no gaps) and cannot branch; no mandates are provided on how to segment the road system except that data providers adopt a consistent method. Road Segment is the real world manifestation of the TRN_Segment as described in the Base Transportation Standard.

Road system – that part of the transportation system that relates to roadways or their appurtenances such as roadway signs or signals

4 Symbols (and abbreviations)

Symbols and associated abbreviations applicable to this standard are listed below. Other, more general transportation abbreviations are found in the Base Transportation Standard.

GOS – Geospatial One Stop

LRS – Linear Referencing System

LRM – Linear Referencing Method

ROD – Three letter mnemonic used to designate the Road subtheme of the Transportation theme

TRN – Three letter mnemonic used to designate the Transportation theme

5 The GOS Feature Meta Model

5.1 Semantics

A feature is an abstraction of a real world phenomenon that is of interest to the application. Instances of features that share common characteristics are organized in classes. Classes are object realizations of the Metaclasses defined in the ISO Rules for Application Schemas Standard (ISO 19109) [7], and instances of the types described in the ISO Feature Catalogs Standard (ISO 19110) [8]. Road Segments and Intersections are examples of Feature Types.

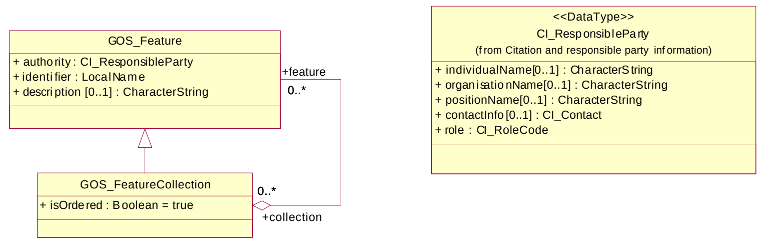

Figure 1–The GOS Metafeature Model

Figure 1 shows GOS_Feature, which is an object realization of the metaclasses defined in the ISO feature model. Features have names, "LocalName" that are unique within the namespace of the feature collection or the database in which they exist. GOS_Feature has a mandatory attribute called "source". The source attribute has type CI_ResponsibleParty, which is defined in ISO 19115 [9]. It provides standardized method for citing a resource as well as information about the source agency or party responsible (CI_ResponsibleParty) for a resource. The CI_ResponsibleParty data type contains the identity of person(s), and/or position, and/or organization(s) associated with the resource.

GOS_FeatureCollection is a collection of features. Feature collection is an aggregate of zero or more features. Feature collections are also features and therefore can have their own attributes and feature names. Feature collections can be, but not in all cases, defined as ordered lists.

6 Road System

6.1.1 Semantics

The Road system models the geographic locations, interconnectedness, and characteristics of the street and roads in the larger transportation system. The Transportation system includes physical and non-physical components representing all modes of travel that allow the movement of goods, services, and people between locations.

The road infrastructure is a physical component of the entire Transportation system, generally consisting of public ways with perhaps a number of carriageways, and perhaps paved, such as one might find in the North American origins of this document. The Transportation theme, therefore includes sub themes, or different modes of transportation. Geospatial data depicting road, rail, transit, inland waterways and airport facilities represent the subthemes of the Transportation infrastructure included in the GOS suite of standards. This document deals only with the road infrastructure.

Three main features are identified in this Road model. These are segments, points and feature events. Segments are portions of the physical Transportation system that are defined by the application domain using some business rules that may vary according to the business and technical requirements. To ensure maximum utility in a variety of contexts, this Road model does not prescribe any specific business rules for the segmentation of the road system. The focus of these standards is to define a way to encode segments, their start and end points, and their attributes, which may have different values along each segment. The model has three main components:

1. A Segmentation Model, which defines segments, collections of segments and their associated geometries and topology.

2. An Event Model, which defines a method to model attributes that may have values that change along the length of a segment.

3. A Linear Reference Model (LRM), which defines a measurement method used apply attributes to segments by locating their endpoints and define their extent. Strictly speaking, the LRM is not a part of this model, but is referenced because of the part it plays in handling the attribution for road features. The LRM is described in full in the Base Transportation Standard, Annex A.

6.2 Segmentation Model

6.2.1 Semantics

A Road Feature is any type of feature that constitutes or is associated with the Road system. As shown in Figure 2, TRN_Feature has three subtypes: TRN_Seg, TRN_Point, and TRN_Path. TRN_Seg, TRN_Point, and TRN_Path are three realizations of the abstract TRN_Feature object metaclasses found in the Base Transportation Standard.

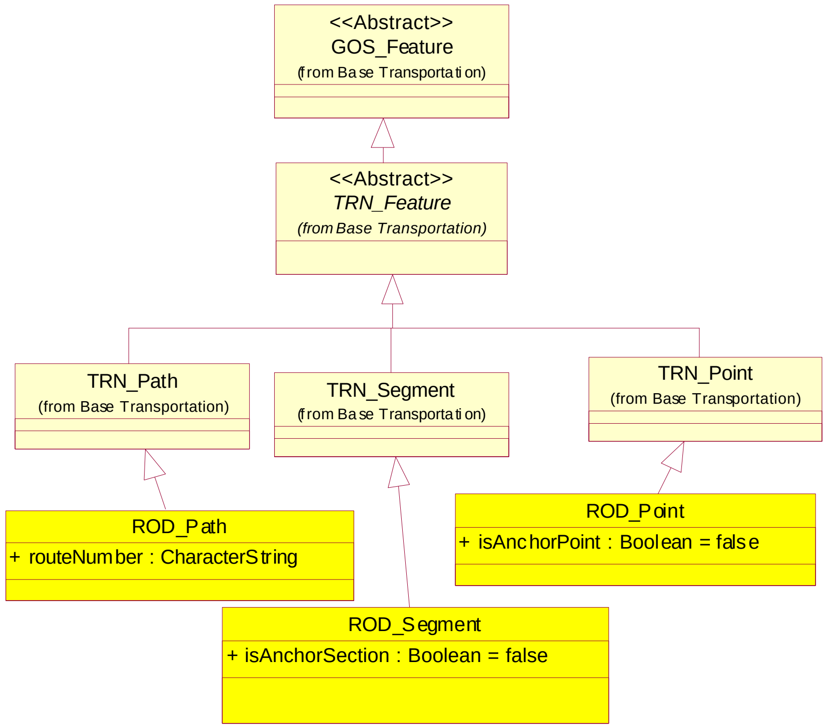

Figure 2-Context diagram: Relationship of Road Features to Base Transportation Model

Figure 2 also show that ROD_Path, ROD_Segment, and ROD_Point are special subclasses of TRN_Path, TRN_Segment, and TRN_Point respectively, and inherit the properties associated with these high level classes. ROD_Path, ROD_Segment, and ROD_Point are the three central features in this model. For a fuller discussion of the general transportation segmentation model, users are advised to consult the GOS Base Transportation Standard.

6.3 ROD_Point

6.3.1 Semantics

ROD_Point is the specified location of an endpoint of a ROD_Segment. This relationship is illustrated in Figure 3, where two ROD_Points, A and B, bound a ROD_Segment. A ROD_Point can also be located along a ROD_Segment as in ROD_Point C or offset from a ROD_Segment as in ROD_Point D.

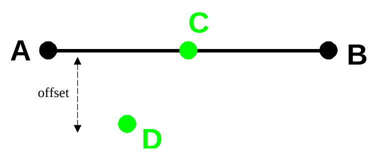

Figure 3–ROD_Points bounding a ROD_Segment (A, B) or independent (C, D)

ROD_Points have geometry of type GM_Point and topology attribute of type TP_Node. Both GM_Point and TP_Node are defined in ISO 19107.

Anchor Point

An anchor point represents a physical location in the field that can be unambiguously described so that it can be clearly located in the real world using the point description. An anchor point is a link between the computer representation of the road system and the real world. An anchor point must occur as the ends of an anchor section. There is no requirement to include anchor points in the dataset being transferred, so not all anchor points are necessarily ROD_Points. Figure 2 shows that ROD_Point has a Boolean attribute indicating whether the point is considered an Anchor Point.

6.4 ROD_Segment

6.4.1 Semantics

ROD_Segment is a linear section of the Earth, which is designed for, or the result of, human or vehicular movement. ROD_Segment extends TRN_Segment and is depicted in Figure 2. Because it extends TRN_Segment, ROD_Segment inherits all properties from TRN_Segment including a geometry of type GM_Curve as defined in ISO 19107. ROD_Segment also has a topology of type TP_DirectedEdge as defined in ISO 19107. According to ISO 19107, GM_Curve extends GM_OrientableCurve and therefore has direction. The reason TP_DirectedEdge has been introduced is to facilitate the representation of feature topology through its combinatorial structures independent of its geometry. For example in the implementation of this model, a data provider may choose to represent only the geometry of a ROD_Segment, which implies a direction inherited from GM_OrientableCurve. Another data provider may choose not to supply road feature geometry and only provide the orientation of the ROD_Segment using its topology attribute.

ROD_Segment has a unique identifier and, as pointed out earlier, is bounded by ROD_Points. A ROD_Segment may have ROD_Points located along its length, which have an association, PointAlong. Locating a ROD_Point along a ROD_Segment is accomplished through the LRM.

6.4.2 Equivalence

Different Transportation agencies may define their segments differently. In Figure 3, one agency has defined segment 1-1 extending from A to B. Another agency can add segments 2-1 and 2-2 using endpoints “A” and “B,” as well as a new point “D.” The equivalence relationship on the ROD_Segment class provides the ability to indicate that a segment is equivalent to one or more segments. For example, segments 2-1 and 2-2 are equivalent to segment 1-1. The defining agency can add attributes related to topology on the segment, or attributes that are related to physical characteristics on the road.

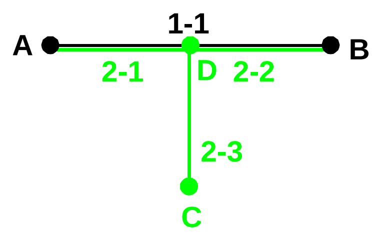

Figure 3–Creating subsegments from main segments

ROD_Segment is a specified directed path between two ROD_Points along a physical road system that identifies a unique segment of that system. Each segment has an identifier, with points used to start and end segments. It is important to note here that a ROD_Segment does not necessarily have to be a road. It could be a lane or a median. Furthermore, a segment is not defined as a line on a map, but as a segment of physical road, of which the beginning, end, and length are determined by Transportation agencies based on their business needs. The agencies determine where the junctions of segments are placed.

6.4.3 Anchor Section

An anchor section represents a section of roadway between two known and recoverable locations, i.e., anchor points. Figure 5 shows the relationship of anchor sections to all ROD_Segments. Anchor sections state the official length of a roadway segment. Anchor points say where the segment starts and ends. The function of anchor sections is to support the collection of data by providing an "all distances measured on this piece of road must add up to this length" checksum. Figure 2 shows that ROD_Segment has a Boolean attribute indicating whether the segment is considered an anchor section.

6.5 ROD_Path

6.5.1 Semantics

ROD_Path is an ordered list of complete or partial ROD_Segments. ROD_Path extends TRN_Path as shown in Figure 2. It is an instance of the ordered feature collection meta-model shown in Figure 1. This means that members of the feature collection can be all or parts of road segments, and may or may not be contiguous. An example of ROD_Path is an Interstate highway such as Interstate 40. The geometry of ROD_Path is GM_CompositeCurve, which is used to represent features whose geometry could also be represented as curve primitives, including ROD_Segments. The topology of ROD_Path is TP_DirectedEdge and RouteNumber is a character string.

6.6 Attributes for Road system

Listed below in table 1 are the Road objects and their attributes. The 'definition' column gives a brief definition of the term. The 'M' and 'O' in the 'Obligation/Condition' column stand for 'Mandatory' and 'Optional'. The 'Maximum Occurrence' column indicates whether there are one or more occurrences. 'Data type' shows how the object is encoded. The 'Domain' column shows the object type.

Table 1 – Transportation System Objects

	Name / Role name	Definition	Obligation / Condition	Maximum occurrence	Data type	Domain
1.	AttributeValue	attribute or feature event	O	1	CharacterString	TRN_Event
2.	Source	source responsible for attribution	M	1	CI_ResponsibleParty	TRN_Event
3.	ROD_LinearAttributeEvent	linear attribute	O	*	Dependent Class	
4.	ROD_LinearAttributeEvent Type	type of linear event	M	*	Class <<CodeList>>	
5.	startPosition	start of the event	M	1	LR_positionExpression	ROD_LinearAttributeEvent
6.	endPosition	end of the event	M	1	LR_positionExpression	ROD_LinearAttributeEvent
7.	ROD_PointAttributeEvent	point attribute	O	*	Dependent Class	
8.	atPosition	position of attribute	M	1	LR_PositionExpression	ROD_PointAttributeEvent
9.	ROD_PointAttributeEventType	type of point event	M	1	Class <<CodeList>>	ROD_PointAttributeEvent
10.	geometry	geometric description	M	1	GM_Primitive	ROD_PointFeatureEvent, ROD_LinearFeatureEvent
11.	ROD_PointFeatureEvent	point feature attribute	O	*	Dependent Class	
12.	atPosition	position of attribute	M	1	LR_PositionExpression	ROD_PointFeatureEvent
13.	ROD_PointFeatureEventType	type of point event	O	1	Class <<CodeList>>	ROD_PointFeatureEvent
14.	ROD_LinearFeatureEvent	linear feature attribute	O	*	Dependent Class	
15.	startPosition	start of feature event	M	1	LR_PositionExpression	ROD_LinearFeatureEvent
16.	endPosition	end of feature event	M	1	LR_PositionExpression	ROD_LinearFeatureEvent
17.	ROD_Path	ordered collection of segments			Specialized Class (ROD_Feature)	
18.	*Role name:* aggregateOf	ordered list of segments that compose the Path	M	*	Association	ROD_Seg
19.	ROD_Seg	linear Transportation feature			Specialized Class (TransportationFeature)	
20.	segmentID	identifier for the segment	M	1	CharacterString	Free Text
21.	Status	current status of the road: under construction, design stage, planning stage, etc.	M	1	CharacterString	Free Text
22.	fieldMeasure	length of measure as taken out in the field	M	1	CharacterString	Free Text
23.	lastUpdateDate	date the segment was entered into the database	M	1	Class	Date
24.	authorityID	identifier for the responsible party for the segment	M	1	CharacterString	Free Text
25.	Length	length of the segment	M	1	CharacterString	Free Text
26.	lengthMeasure	unit of measure of the length	M	1	CharacterString	Free Text

	Name / Role name	Definition	Obligation / Condition	Maximum occurrence	Data type	Domain
27.	geometry	geometric description of the segment	O	1	GM_Curve	Integer
28.	topology	topological relationships	O	1	TP_DirectedEdge	
29.	*Role name:* Near	point located near the segment	O	*	Association	ROD_Point
30.	*Role name:* Along	point located along the segment	O	*	Association	ROD_Point
31.	*Role name:* End	endpoint for the segment	M	1	Association	ROD_Point
32.	*Role name:* Start	start-point for the segment	M	1	Association	ROD_Point
33.	*Role name:* From	starting segment for equivalence	O	*	Association	ROD_Seg
34.	*Role name:* To	end segment for equivalence	O	*	Association	ROD_Seg
35.	*Role name:* Event	event(s) located on or near the segment or path	O	*	Association	Event
36.	*Role name:* referentList	list of referents along a linear element (e.g., reference posts)	O	*	Association	Referent
37.	*Role name:* offsetReferentList	list of referent lines offset left or right of the linear element centerline	O	*	Association	Referent
38.	ROD_Point	point road feature			Specialized Class (TransportationFeature)	
39.	Point_ID	identifier for the point	M	1	CharacterString	Free Text
40.	description	description of the point	M	1	CharacterString	Free Text
41.	*Role name:* Along	segment the point is located along	O	*	Association	ROD_Seg
42.	*Role name:* End	road segment for which the point is an endpoint	O	*	Association	ROD_Seg
43.	*Role name:* Start	road segment for which the point is a start-point	O	*	Association	ROD_Seg

7 The Event Model

7.1 Attribute Event

An attribute event is a concept that handles characteristics, both physical and non-physical, of Road components. Attribute events may alter the attributes of the associated Road feature. An attribute event occurs within a defined time period at a defined location. Attribute events are further divided into two broad classes: ROD_LinearAttributeEvent and ROD_PointAttributeEvent. Figure 4 shows the attribute event model and shows that ROD_LinearAttributeEvent and ROD_PointAttributeEvent are realizations of the metaclasses TRN_LinearAttributeEvent and TRN_PointAttributeEvent from the Base Transportation model.

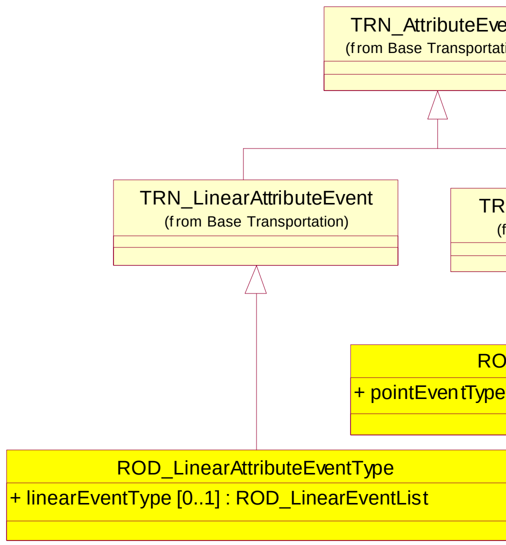

Figure 4-The Attribute Event Model

Attribute events are those types of characteristics that have different values at different stretches along a ROD_Segment. For example, using the event model we can encode speed limit of 55 miles per hour for the first three miles of a segment and 65 miles per hour for the remainder of the segment.

7.2 Linear Attribute Events

7.2.1 Semantics

ROD_LinearAttributeEvents are not physical features, but events that have no geometry. An example of a linear attribute event is a speed limit. ROD_LinearAttributeEvents typically are non-physical characteristics, or those that have a short time horizon. The kinds of linear attribute events are given in a code list, ROD_LinearEventList.

7.3 Point Attribute Events

7.3.1 Semantics

ROD_PointAttributeEvents, like linear attribute events, have no geometry. An example of such an event is a vehicle accident, or other such incident that has a limited temporal representation and can be represented by a point. Like ROD_LinearAttributeEvents, ROD_PointAttributeEvents are reserved for either non-physical events or those with a shorter time horizon. The types of point attribute events are given in a code list, ROD_PointEventList.

7.4 Feature Attribute Events

Feature events are events associated with real world physical features that are associated with or appurtenances to the transportation system, which typically have a longer time horizon than attribute events. Examples of this include the regulatory and informational signage and signals, as well as safety features associated with the road system. Feature events are used when users want to carry persistent information related to the attributes of the road system. Feature attribute events need not be associated with a ROD_Segment or ROD_Path but could be associated with them through the LRM. Feature attribute event is introduced to allow the association of optional geometries to an event so that events can be defined independent of ROD_Segment and ROD_Point.

Feature attribute events are further subdivided into point events and linear events. A point event is anything that occurs at a single point location, such as might occur at a ROD_Point. A linear event is something that occurs along a portion of a ROD_Segment or ROD_Path. Examples of point attribute events are accidents or signs. Examples of linear attribute events are pavement type. Both ROD_LinearAttributeEvents and ROD_PointAttributeEvents are extensions of TRN_LinearAttributeEvent and TRN_PointAttributeEvent respectively.

The location of events is determined using the LRS. (The LRS is discussed in detail in Annex A of the Base Transportation Standard.) For example, a sign located at Mile 6 of the segment at an offset of 15 feet can be modeled using an LRS and the event model.

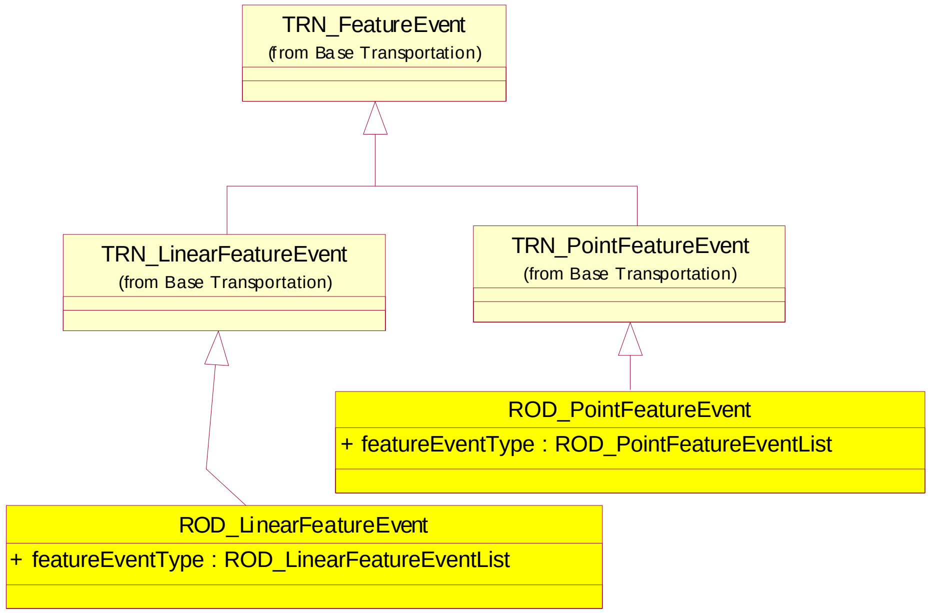

Figure 5-The Feature Event Model

7.5 LinearAttributeEvent

7.5.1 Semantics

Linear attribute events are events that have linear characteristics. Linear attributes events are real features and have a two-dimensional geometry. Linear events are located along ROD_Segments that already have geometry and, because they are real world features, typically have a long time horizon. An example of a linear attribute event is a guardrail, which has a persistent geometry and attributes that may be of interest in the business application. A list of LinearAttributeEvents is provided in Figure 6.

7.6 PointAttributeEvent

7.6.1 Semantics

Point attribute events are also features but have a one-dimensional geometry. Point events are associated with ROD_Segments or ROD_Paths that have geometry. Examples of point attribute events include traffic sign and traffic signal. A list of values for PointAttributeEvent is provided in Figure 6.

Figure 6-Example PointFeatureEvent and LinearFeatureEvent Lists

7.7 Attributes for events

Listed below in table 2 are linear event objects and their associated attributes. The 'definition' column gives a brief definition of the term. The 'M' and 'O' in the 'Obligation/Condition' column stand for 'Mandatory' and 'Optional'. The 'Maximum Occurrence' column indicates whether there are one or more occurrences. 'Data type' shows how the object is encoded. The 'Domain' column shows the object type.

Table 2 – Linear Events

	Name / Role name	Definition	Obligation / Condition	Maximum occurrence	Data type	Domain
44.	LinearAttributeEvent	event between two points	Use obligation from referencing object	Use maximum occurrence from referencing object	Class	
45.	startMeasure	Measure indicating the start of the event	M	1	Class	DistanceExpression
46.	startOffset	Measure indicating the start of the offset	O	1	Class	OffsetExpression
47.	endMeasure	Measure indicating the end of the event	M	1	Class	DistanceExpression
48.	endOffset	Measure indicating the end of the offset	O	1	Class	OffsetExpression
49.	linearReferenceMethod	linear reference method used to define the measures	M	1	Class	LinearReferenceMethod
50.	linearEventType	type of linear event	M	1	Class	LinearEventList <<Codelist>>

Table 3 – Point Events

	Name / Role name	Definition	Obligation / Condition	Maximum occurrence	Data type	Domain
51.	PointAttributeEvent	event at a single location	Use obligation from referencing object	Use maximum occurrence from referencing object	Specialized Class (Event)	
52.	atMeasure	Measure at which the event is located	M	1	Class	DistanceExpression
53.	AtOffset	offset at which the event is located	O	1	Class	OffsetExpression
54.	linearReferenceMethod	linear reference method used to define the measures	M	1	Class	LinearReferenceMethod
55.	pointEventType	type of point even	M	1	Class	PointEventList
56.	*Role Name:* associatedWith	point where the event is located	M	1	Association	ROD_Point

8 Code Lists

Listed below in table 4 is the code list for measurement methods used for Linear Referencing.

Table 4 – Measurement Methods

	Name	Domain code	Definition
1.	MethodType		type of measurement method
2.	absolute	001	location is measured along the linear element starting at the beginning of the linear element
3.	relative	002	location is measured along the linear element starting at the location of a predefined referent
4.	interpolative	003	location along the linear element is determined by applying linear interpolation of the specified measure against the total length of the linear element
5.	projected	004	location along the linear element is determined by projecting the specified spatial location onto the linear element

Annex A UML notations

The material in this annex is drawn from ISO/TS 19103 [11] and ISO 19115. The diagrams that appear in this Standard are presented using the Unified Modeling Language (UML) static structure diagram with the ISO Interface Definition Language (IDL) basic type definitions and the UML Object Constraint Language (OCL) as the conceptual schema language. The UML notations used in this standard are described in Figures 1 and 2.

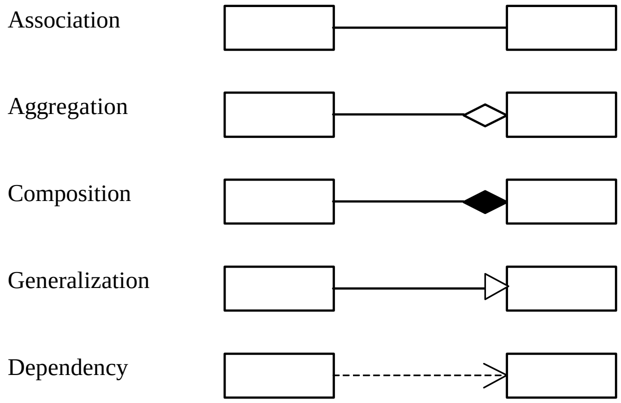

Figure 7–UML notation

UML model relationships

Associations

An association is used to describe a relationship between two or more classes. UML defines three different types of relationships, called association, aggregation and composition. The three types have different semantics. An ordinary association shall be used to represent a general relationship between two classes. The aggregation and composition associations shall be used to create part-whole relationships between two classes. The direction of an association must be specified. If the direction is not specified, it is assumed to be a two-way association. If one-way associations are intended, the direction of the association can be marked by an arrow at the end of the line.

An aggregation association is a relationship between two classes in which one of the classes plays the role of container and the other plays the role of the contained. A composition association is a strong aggregation. In a composition association, if a container object is deleted, then all of its contained objects are deleted as well. The composition association shall be used when the objects representing the parts of a container object cannot exist without the container object.

Generalization

A generalization is a relationship between a superclass and the subclasses that may be substituted for it. The super-class is the generalized class, while the subclasses are specified classes.

Instantiation / Dependency

A dependency relationship shows that the client class depends on the supplier class/interface to provide certain services, such as:

- Client class accesses a value (constant or variable) defined in the supplier class/interface;
- Operations of the client class invoke operations of the supplier class/interface;
- Operations of the client class have signatures whose return class or arguments are instances of the supplier class/interface.

An instantiated relationship represents the act of substituting actual values for the parameters of a parameterized class or parameterized class utility to create a specialized version of the more general item.

Roles

If an association is navigable in a particular direction, the model shall supply a "role name" that is appropriate for the role of the target object in relation to the source object. Thus in a two-way association, two role names will be supplied.

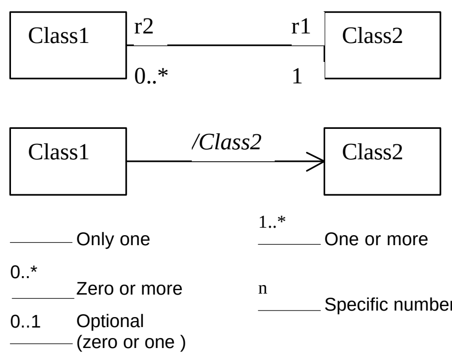

Figure 8–UML roles

Figure 16 represents how role names and cardinalities are expressed in UML diagrams. The role name "r1"' is Class1's relationship to Class2. The role name "r2" is Class2's relationship to Class1. The cardinalities show that "zero or many" Class1s are related to "exactly one" Class2. Figure 2 also shows how derived classes will be expressed. The diagram indicates that Class1 is a derived class of Class2. Any attributes and aggregates of Class1 are also derived from Class2.

UML model stereotypes

A UML stereotype is an extension mechanism for existing UML concepts. It is a model element that is used to classify (or mark) other UML elements so that they in some respect behave as if they were instances of new virtual or pseudo metamodel classes whose form is based on existing base metamodel classes. Stereotypes augment the classification mechanisms on the basis of the built-in UML metamodel class hierarchy. Below are brief descriptions of the stereotypes used in this Standard:

a) <<DataType>> descriptor of a set of values that lack identity (independent existence and the possibility of side effects). Data types include primitive predefined types and user-definable types. A DataType is thus a class with few or no operations whose primary purpose is to hold the abstract state of another class.
b) <<CodeList>> used to describe a more open enumeration. <<CodeList>> is a flexible enumeration. Code lists are useful for expressing a long list of potential values. If the elements of the list are completely known, an enumeration should be used; if the only likely values of the elements are known, a code list should be used.
c) <<Abstract>> class (or other classifier) that cannot be directly instantiated. UML notation for this to show the name in italics.
d) <<Package>> cluster of logically related components, containing sub-packages.
e) <<Leaf>> package that contains definitions, without any sub-packages.